Feb. 17, 1953 C. J. COBERLY 2,628,563

FLUID-OPERATED PUMP WITH DOUBLE-ACTING DIRECT-CONNECTED BOOSTER PUMP

Filed Feb. 21, 1949 2 SHEETS—SHEET 1

Fig. 1

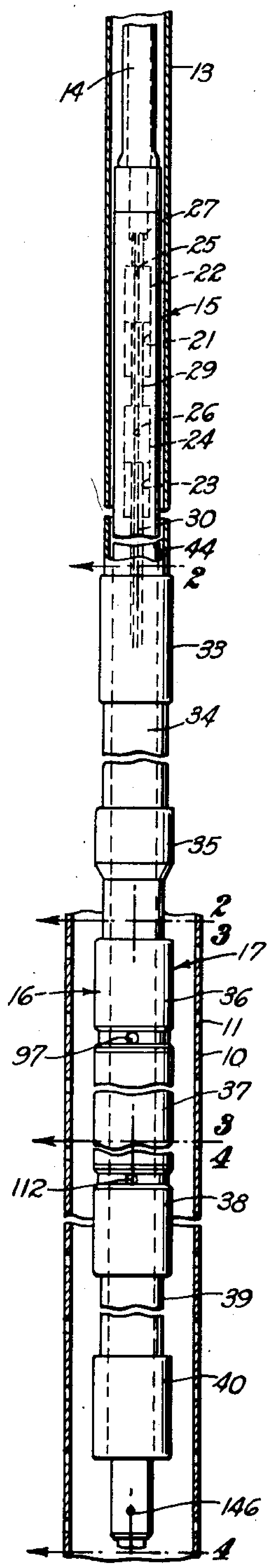


Fig. 5

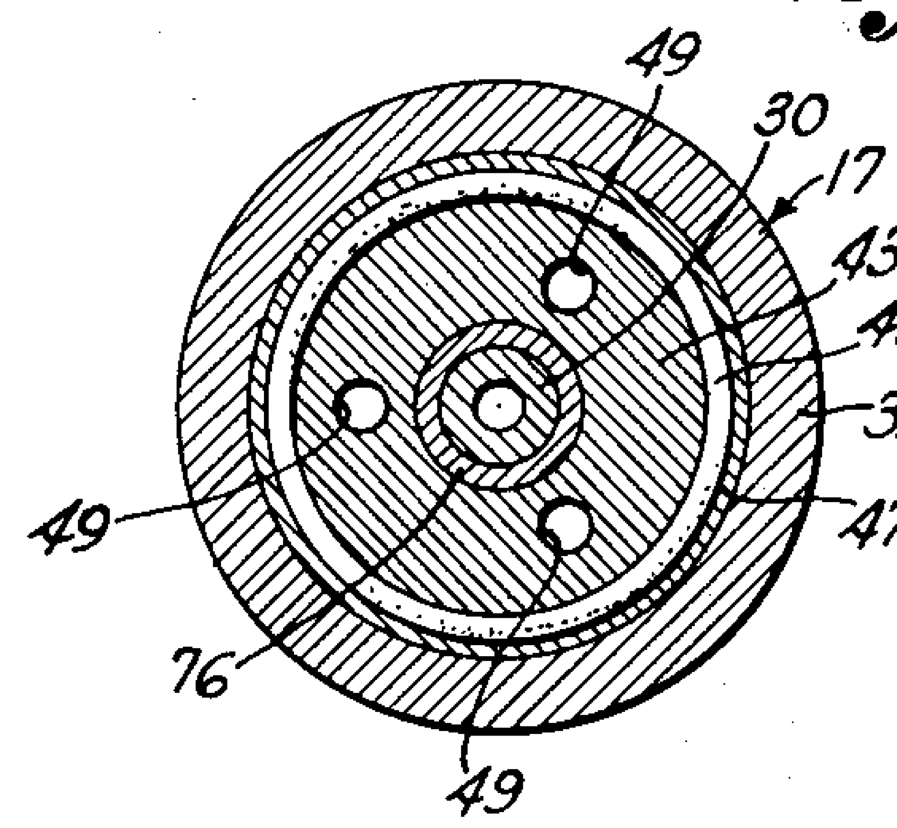


Fig. 6

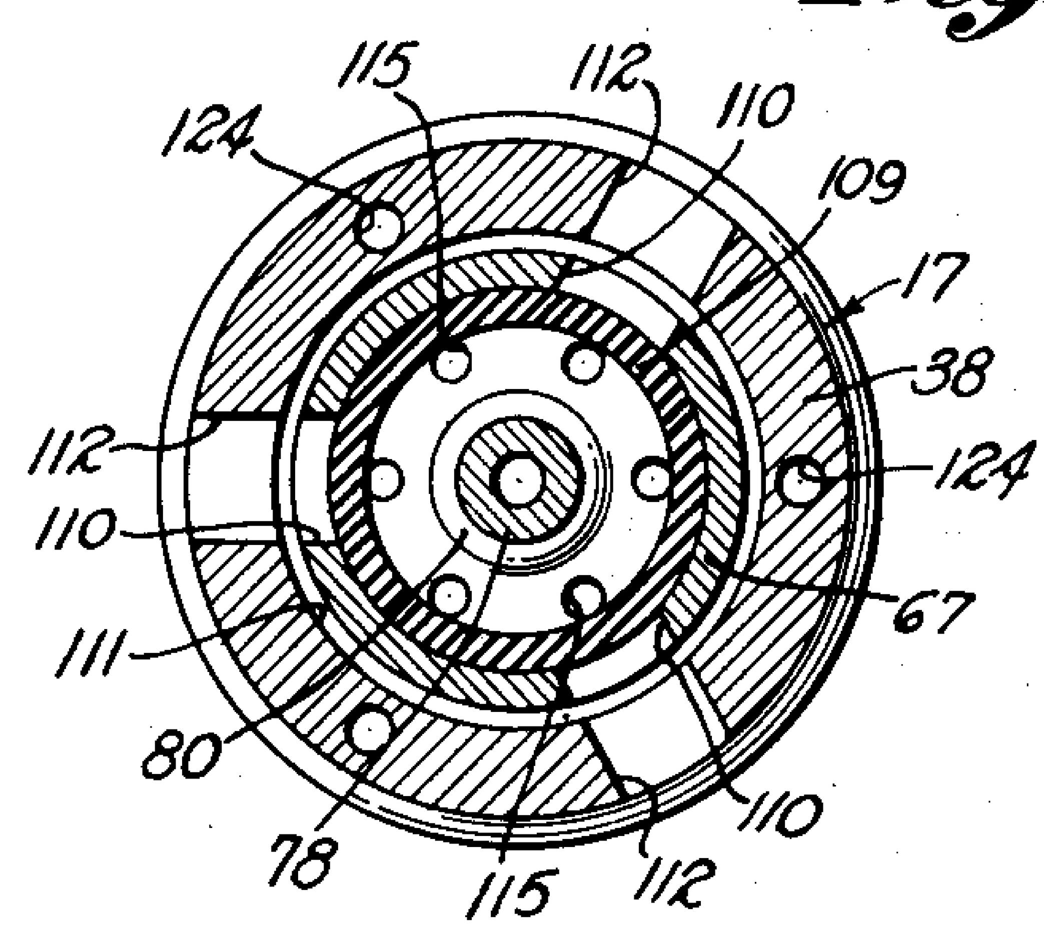
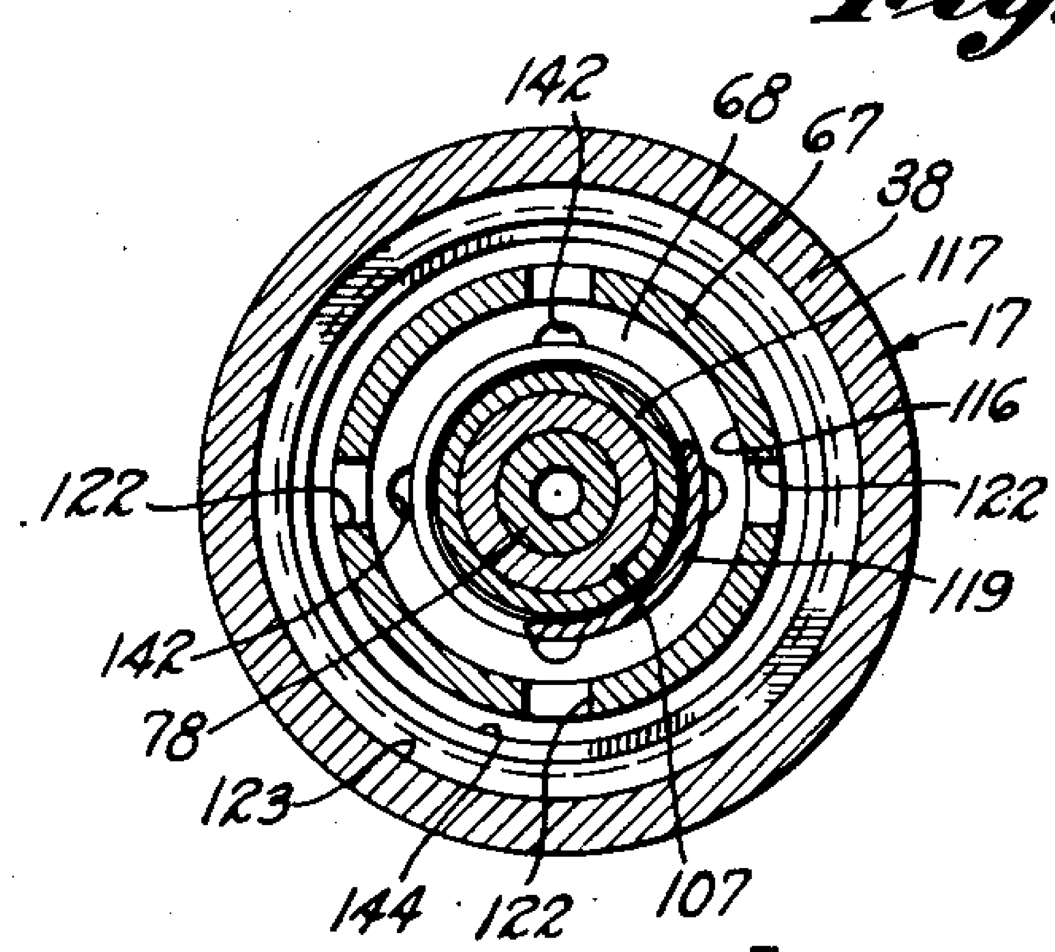


Fig. 7



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FLUID-OPERATED PUMP WITH DOUBLE-ACTING DIRECT-CONNECTED BOOSTER PUMP

Filed Feb. 21, 1949 2 SHEETS—SHEET 2

Fig. 2

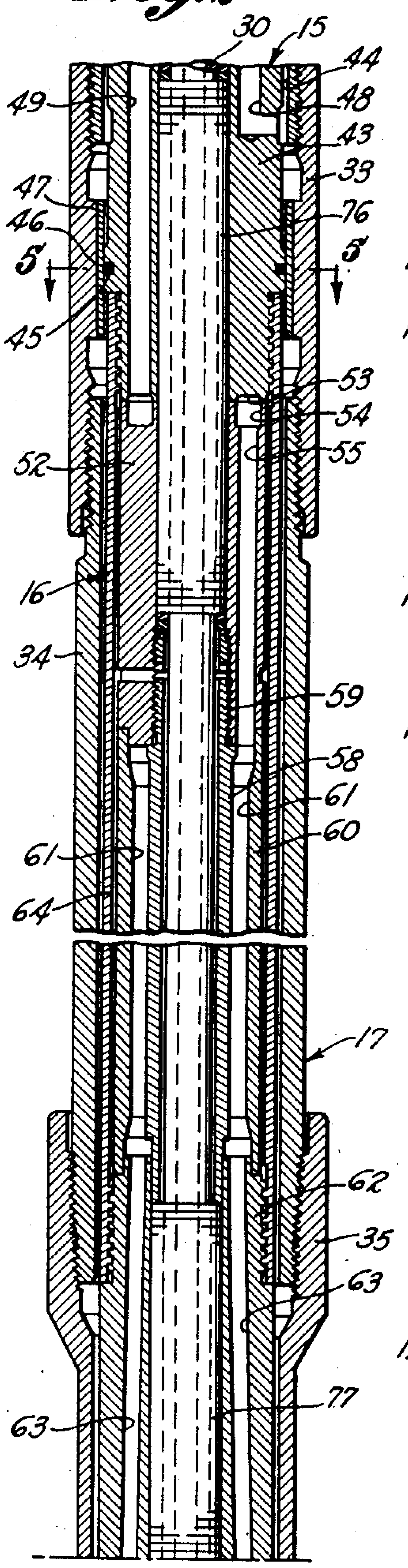


Fig. 3

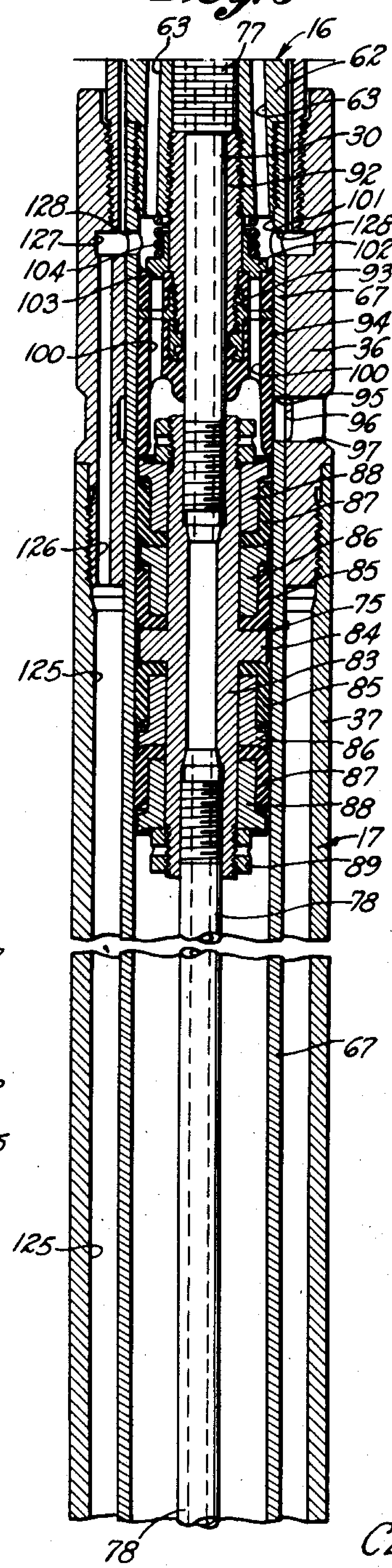
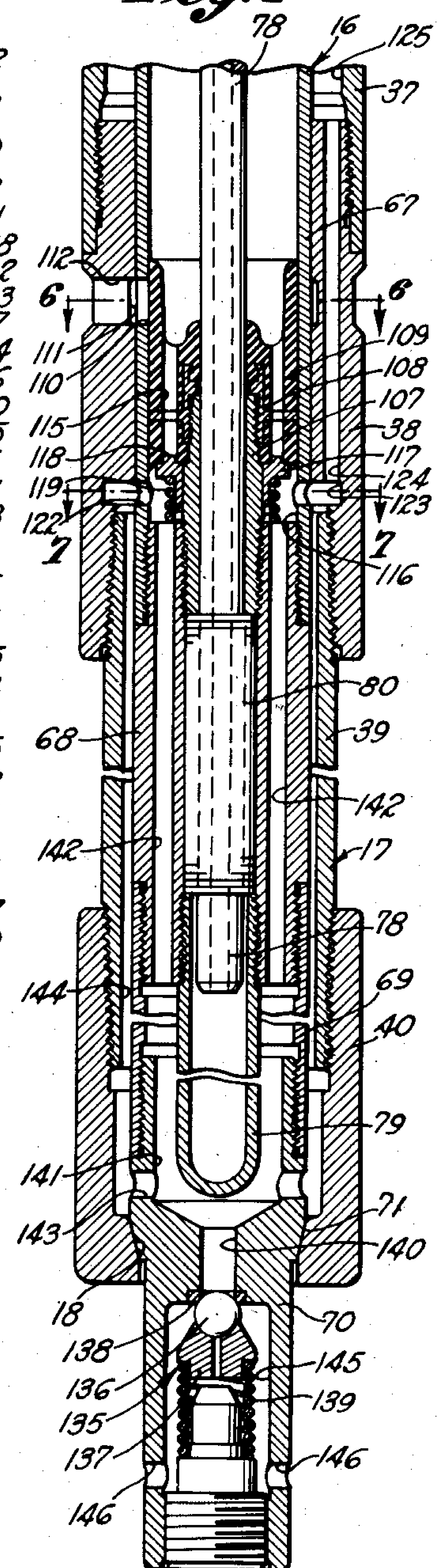


Fig. 4



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UNITED STATES PATENT OFFICE

2,628,563

FLUID-OPERATED PUMP WITH DOUBLE-ACTING DIRECT-CONNECTED BOOSTER PUMP

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Application February 21, 1949, Serial No. 77,588

9 Claims. (Cl. 103—5)

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My invention relates to fluid-operated pumps for wells, and, more particularly, to a fluid-operated pumping device comprising a fluid-operated main pump having an auxiliary or booster pump associated therewith for increasing the pressure of the well fluid delivered to the inlet of the main pump above that obtaining at the intake of the booster pump.

Fluid-operated pumps are commonly used in the oil industry for pumping oil from wells, such a pump comprising, in general, a coupled motor and pump combination set in the well at the level from which oil is to be pumped. In such a combination, the motor comprises a motor piston which is actuated by alternatively admitting an operating fluid, such as clean crude oil, under relatively high pressure into opposite ends of a motor cylinder in which the motor piston is disposed so as to reciprocate the motor piston. The reciprocating motion of the motor piston is communicated to a pump piston in the pump section of the combination so that the pump piston pumps oil from the well.

The fluid being pumped from a well may contain, in addition to oil, various other fluids such as water and natural gas, the gas being present in solution or in suspension in the oil in varying quantities depending upon the pressure and temperature conditions prevailing in the well. Also, if the well is being pumped beyond its capacity to produce, air may be present in the fluid being pumped. If the oil is saturated or super-saturated with natural gas at the conditions of pressure and temperature prevailing at the level at which the pump is set, a large portion of the gas may be released during the suction stroke of the pump piston to form a gas pocket in the pump cylinder. Also, of course, in many wells the well fluid is merely a froth composed largely of gas with a relatively small volume of oil. In either case, or if air is drawn into the pump cylinder, a pocket of gas or air in the pump cylinder results. Such pockets result in a material reduction in the pumping load until such time as the pump piston compresses the gas or air present and strikes solid well fluid in the cylinder.

Such fluid-operated pumps are frequently set at relatively great depths and, consequently, a large volume of operating fluid under relatively high pressure is confined in the supply tubing between the pump in the well and the apparatus on the surface which delivers the operating fluid to the pump. Due to the appreciable compressibility of this large volume of operating fluid, and due to the expansion of the supply tubing under

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the relatively high pressure at which the operating fluid is maintained, a large amount of energy is stored under normal operating conditions. If, because of the presence of gas or air in the pump cylinder, the load on the pump piston decreases, a sudden increase in the rate of flow of operating fluid to the pump occurs, thereby accelerating the motor and pump pistons. The speed ultimately attained may be excessive and the pump may race for a portion of a stroke, or for a number of strokes, which is normally detrimental to various components of the pump. Various expedients for preventing damage to the pump mechanism under such conditions have been employed. For example, flow regulators disposed in the supply line for the operating fluid have been employed to maintain the rate of delivery of operating fluid to the motor section of the pump below a value which might be harmful to the pumping equipment. While such flow governors are practical under most conditions of operation, they have some disadvantages in that they increase the cost of the pumping equipment and render the equipment rather complicated. Also, there is some lag in their operation since they respond only after the condition requiring compensation has already developed.

Also, the presence of gas or air in the pump cylinder has a detrimental effect on the efficiency of such a fluid-operated pump. For example, if, in a given installation, thirty percent of the pump cylinder of the fluid-operated pump contains free gas or air, the efficiency of the pump, i. e., the percentage of the volume of the pump cylinder which contains solid well fluid, will be only seventy percent. In other words, under such conditions, the fluid-operated pump will pump well fluid from the well at only seventy percent of capacity.

In view of the foregoing considerations, it is a primary object of the present invention to provide, in combination with a conventional fluid-operated pump, an auxiliary or booster pump which is adapted to draw well fluid from the well and to deliver it to the inlet of the fluid-operated pump at an increased pressure such that the major portion of the gas or air in the well fluid will not flash out to form a pocket in the pump cylinder of the main pump. I accomplish this by providing a booster pump which will maintain the pressure of the well fluid passing into the pump cylinder of the main pump at a value equal to or above the pressure prevailing in the well at the inlet of the pumping device. A further object of the invention is to provide a booster pump which will compress any free gas or air entrained in the well fluid to a substantial extent before it is delivered to the inlet of the main pump.

It will be apparent that employing a booster pump in combination with a fluid-operated main pump in the foregoing manner will obviate, or at least minimize, the difficulties hereinbefore discussed. In other words, the employment of a booster pump will tend to obviate the racing of the main pump and to increase the pumping efficiency thereof. As an example, let it be assumed that the pumping efficiency of the main pump is only seventy percent when the pressure at the inlet thereof is approximately equal to atmospheric pressure. With the present invention, if the particular booster pump utilized is adapted to increase the pressure of the well fluid delivered to the inlet of the main pump to three hundred pounds per square inch, the free gas or air which otherwise would occupy thirty percent of the volume of the pump cylinder of the main pump will be compressed to occupy only approximately 1.4 percent of the volume of the pump cylinder, thereby increasing the efficiency of the main pump to approximately 98.6 percent under such conditions.

Another object of the present invention is to provide such a pumping device, i. e., such a fluid-operated main pump and booster pump combination, in which the booster pump is directly connected to the main pump so as to be operable thereby. More specifically, it is an object to provide a fluid-operated pumping device wherein the booster pump includes a booster pump piston directly connected by rod means to one of the pistons of the main pump, preferably the pump piston thereof.

A further object of the invention is to provide in such a pumping device a booster pump of the double-acting type so as to maintain substantially constant pressure at the inlet of the main pump.

Another object is to provide such a pumping device wherein the main and booster pumps are removable as a unit.

Still another object is to provide a pumping device of the character mentioned wherein the main and booster pumps are insertable into a tubular receiver which provides a seat.

A further object is to provide a booster pump having pressure relief valve means for by-passing fluid discharged by the booster pump piston to the well in the event that the pressure of the fluid delivered to the inlet of the main pump tends to exceed a predetermined value.

Another object of the invention is to provide a pumping device wherein the rod means connecting the various pistons of the main and booster pumps is hydraulically balanced with respect to operating fluid pressure.

The foregoing objects and advantages of the present invention, together with various other objects and advantages thereof which will become apparent, may be attained through the employment of the exemplary embodiment of the invention which is illustrated in the accompanying drawings and which is described in detail hereinafter.

Referring to the drawings:

Fig. 1 is a utility view on a reduced scale showing a fluid-operated pumping device which embodies the invention as installed in a well;

Fig. 2 is a longitudinal sectional view of the upper end of a preferred booster pump of the invention and is taken along the broken line **2—2** of Fig. 1 of the drawings;

Fig. 3 is a downward continuation of Fig. 2 and is taken along the broken line **3—3** of Fig. 1;

Fig. 4 is a downward continuation of Fig. 3 and is taken along the broken line **4—4** of Fig. 1;

Fig. 5 is a tranverse sectional view taken along the broken line **4—4** of Fig. 2; and,

Figs. 6 and 7 are transverse sectional views respectively taken along the broken lines **6—6** and **7—7** of Fig. 4.

Referring particularly to Fig. 1 of the drawings, I show an oil well lined with a casing **10** having perforations **11** which register with an oil producing formation through which oil and other fluids may flow into the interior of the casing, the fluids entering the casing being collectively referred to hereinafter as the well fluid. Extending downwardly into the casing **10** is a production tubing **13** which is adapted to convey well fluid to the surface of the ground, and extending downwardly into the production tubing in the particular construction illustrated is a power tubing **14** having a fluid-operated main or primary pump **15** connected to the lower end thereof. Connected to the lower end of the main pump **15** is an auxiliary or booster pump **16** which is adapted to pump well fluid from the casing **10** to the inlet of the main pump at a pressure higher than that obtaining at the intake of the booster pump, as will be discussed in more detail hereinafter. The main and booster pumps **15** and **16** extend into a tubular receiver **17** which, in effect, forms an extension of the production tubing **13** and which is secured to the lower end thereof, the main and booster pump assembly seating on a tapered seat **18** at the lower end of the receiver **17**, as shown in Fig. 4 of the drawings.

The fluid-operated main pump **15** may be of any conventional type, such as that shown in my Patent No. 2,081,220, issued May 25, 1937, which is adapted to pump well fluid from the casing **10** upwardly through the production tubing **13** to the surface. As shown diagrammatically in dotted lines in Fig. 1 of the drawings, the fluid-operated main pump **15** is provided with a motor cylinder **21** having a motor piston **22** therein, and is provided with a pump cylinder **23** having a pump piston **24** therein, the motor and pump pistons respectively being provided with longitudinal passages **25** and **26** therethrough. Connected to the upper end of the motor piston **22** and communicating with the passage **25** therethrough is an upper tubular rod **27**. Connecting the motor and pump pistons **22** and **24** and communicating with the respective passages **25** and **26** therethrough is an intermediate tubular rod **29**, and connected to the lower end of the pump piston is a lower tubular rod **30** for directly connecting the main pump **15** to the booster pump **16** as will be discussed in more detail hereinafter.

Briefly, the fluid-operated main pump **15** operates as follows: operating fluid, such as clean crude oil, under relatively high pressure is alternately admitted into opposite ends of the motor cylinder **21** to reciprocate the motor piston **22** therein, such reciprocatory motion of the motor piston being communicated to the pump piston **24** by the intermediate tubular rod **29**. The pump piston **24** discharges fluid into the production tubing **13**, which conveys the fluid upwardly to the surface.

Considering the pumping device in more detail, the tubular receiver **17**, which, as previously indicated, is connected to the lower end of the production tubing 13, includes a plurality of components, one of these being a tubular coupling 33 which is threaded onto the lower end of the production tubing, as best shown in Fig. 2 of the drawings. Threaded into the coupling 33 is a sleeve 34 and threaded onto this sleeve is another tubular coupling 35 having a portion of reduced diameter which is threaded into a tubular intake fitting 36, as best shown in Fig. 3 of the drawings. Threaded onto the lower end of the intake fitting 36 is a sleeve 37 and, as best shown in Fig. 4, threaded into the lower end of this sleeve is another tubular intake fitting 38. Another sleeve 39 is threaded into the lower end of the intake fitting 38 and threaded onto the lower end of the sleeve 39 is a tubular pump seat member 40 which provides the previously mentioned pump seat 18.

Referring to Fig. 2 of the drawings, the main pump 15 terminates at its lower end in a tubular inlet and discharge fitting 43 which is of smaller diameter than the internal diameter of the production tubing 13 to provide an annular space 44 through which well fluid discharged by the main pump may flow upwardly. The annular space 44 is closed at its lower end when the main and booster pumps 15 and 16 are in their operating positions by a sealing ring 45 which is carried in an annular groove 46 in the fitting 43 and which is adapted for fluid-tight engagement with a sleeve 47 pressed into the tubular coupling 33. Well fluid discharged by the main pump 15 enters the annular space 44 within the production tubing 13 through discharge passages 48 in the fitting 43, only one of these discharge passages being visible in Fig. 2 of the drawings. The fitting 43 is also provided with longitudinal passages which serve as inlet ports 49 for the main pump 15, these inlet ports being shown best in Fig. 5 of the drawings.

Considering the booster pump 16 in more detail, it includes a tubular fitting 52 which is seated against the lower end of the fitting 43, the fittings 43 and 52 respectively being provided with registering annular grooves 53 and 54 which communicate with the inlet ports 49 in the fitting 43. The fitting 52 is provided with a plurality of longitudinal passages 55 therethrough, only one of which is visible in Fig. 2 of the drawings, which also communicate with the registering annular grooves 53 and 54.

Seated against the lower end of the fitting 52 is a tubular fitting 58 having a stem 59 which is threaded into the fitting 52. Also seated against the lower end of the fitting 52 is another tubular fitting 60 having an internal diameter which is greater than the external diameter of the fitting 58 to provide an annular passage 61 therebetween, the passage 61 communicating with the lower ends of the longitudinal passages 55 through the fitting 52.

Seated against the lower end of the fitting 60 is a tubular discharge 62 having a plurality of longitudinal passages 63 therethrough which communicate at their upper ends with the annular passage 61, the passages 63 being regarded as discharge ports for the booster pump 16 as will be discussed in more detail hereinafter. A sleeve 64 encloses the fittings 52 and 60 and is threaded at its ends onto the fittings 43 and 62 to clamp the fittings 43, 52, 60 and 62 together.

Referring particularly to Fig. 3 of the drawings, threaded onto the lower end of the discharge fitting 62 is a booster pump cylinder 67. The external diameter of the booster pump cylinder approaches the internal diameters of the intake fittings 36 and 38 so as to make substantially fluid-tight contact therewith, but is slightly less than the internal diameters of the intake fittings so as to permit insertion of the booster pump 16 into and withdrawal thereof from the tubular receiver 17.

Threaded into the lower end of the booster pump cylinder 67 is a tubular fitting 68 and connected to the lower end of this fitting by a coupling 69 is a member 70 having a tapered external surface 71 which is adapted to engage the pump seat 18 to support the main and booster pumps 15 and 16.

Referring particularly to Figs. 2 and 3 of the drawings, the lower tubular rod 30 of the main pump 15 extends downwardly from the pump piston 24 of the main pump through the tubular fittings 43, 52, 58 and 62 into the booster pump cylinder 67 wherein it is threaded into a tubular booster pump piston 75, suitable packings 76 and 77 respectively being provided between the rod 30 and the fittings 43, 52 and between the rod 30 and the fittings 62. As best shown in Figs. 3 and 4 of the drawings, a tubular rod 78 is threaded into the lower end of the tubular pump piston 75 and projects from the lower end of the booster pump cylinder 67 through the tubular fitting 68 into a balance chamber 79 which is threaded into the fitting 68, suitable packing 80 being provided between the rod 78 and the fitting 68.

It will be apparent that with this construction, the main and booster pumps 15 and 16 are hydraulically balanced insofar as the transverse rod areas are concerned, the upper end of the upper tubular rod 27 of the main pump being exposed to operating fluid pressure in the power tubing 14, as shown in Fig. 1 of the drawings, and the lower end of the tubular rod 78 being exposed to operating fluid pressure in the balance chamber 78, as shown in Fig. 4 of the drawings. Operating fluid enters the balance chamber 79 through the upper tubular rod 27, the passage 25 through the motor piston 22 of the main pump, the intermediate tubular rod 29, the passage 26 through the pump piston 24 of the main pump, the lower tubular rod 30, the tubular booster pump piston 75 and the tubular rod 78.

Considering the booster pump piston 75 in more detail and referring particularly to Fig. 3 of the drawings, it includes a tubular core 83 into which the tubular rods 30 and 78 are threaded, this core having an external flange 84 thereon intermediate its ends. Seated against opposite sides of the flange 84 are oppositely disposed packing cups 85 which are formed of a flexible and resilient material such as leather, oil-resistant rubber, or the like. Extending into and seated against the base wall of each packing cup 85 is a spacer 86 and seated against each spacer 86 is a packing cup 87, the packing cups 87 being oppositely disposed and being identical to the packing cups 85. Extending into and seated against the base walls of the packing cups 87 are spacers 88, the latter being engaged by nuts 89 threaded on the ends of the cores 83 to hold the components of the booster pump piston 75 in assembled relationship.

Referring particularly to Fig. 3 of the drawings, threaded into the tubular fitting 62 at the upper end of the booster pump cylinder 67 and encircling the rod 30 is a sleeve 92 and threaded onto this sleeve is an insert 93 which is embedded in an intake valve 94 of the cup type, the intake valve being formed of a flexible and resilient material. Preferably, the valve 94 is formed of a rubber-like material of an oil-resistant nature, such as "neoprene," for example. The intake valve 94 is provided with a skirt which is adapted to close intake ports 95 in the booster pump cylinder 67 when the pressure within the booster pump cylinder exceeds that in the intake ports and which is adapted to be deformed inwardly to open the intake ports when the pressure in the cylinder 67 is reduced below that in the intake ports. The intake ports 95 communicate with an internal annular groove 96 formed in the upper intake fitting 36, the groove 96 in turn communicating with the well through intake ports 97 in the fitting 36.

The intake valve 94 is provided with a plurality of longitudinal passages 100 therethrough which communicate with the discharge ports 63 through an annular space 101 between the fitting 62 and the valve 94. Disposed in the annular space 101 and encircling the sleeve 92 is a discharge valve 102 having projections 103 which are insertable into the passages 100 in the intake valve 94 to close them, the discharge valve being biased toward its closed position by a spring 104 which is seated against the lower end of the discharge fitting 62. The spring 104 is adapted to permit the discharge valve 102 to open when the pressure in the booster pump cylinder 67 above the booster pump piston 75 exceeds the pressure in the discharge ports 63, and to close the discharge valve when such pressure is less than that in the discharge ports.

Referring now to Fig. 4 of the drawings, threaded into the tubular fitting 68 at the lower end of the booster pump cylinder 67 is a sleeve 107 onto which is threaded an insert 108 embedded in an intake valve 109 which is identical to the intake valve 94, the intake valve 109 controlling flow through intake ports 110 in the booster pump cylinder. The intake ports 110 communicate with an internal annular groove 111 in the lower intake fitting 38, which groove in turn comunicates with the well through intake ports 112 in the fitting 38.

The intake valve 109 is provided with longitudinal passages 115 therethrough which correspond to the longitudinal passages 100 through the intake valve 94 and which communicate with an annular space 116 between the fitting 68 and the intake valve 109. Disposed in the annular space 116 and encircling the sleeve 107 is a discharge valve 117 having projections 118 which are insertable into the longitudinal passages 115 to close them, the discharge valve 117 being identical to the discharge valve 102 and being biased toward its closed position by a spring 119 which is seated against the fitting 68.

Referring to Figs. 4 and 7 of the drawings, communicating with the annular space 116 containing the discharge valve 117 is a plurality of radial ports 122 in the booster pump cylinder 67, these ports communicating with an annular groove 123 in the lower intake fitting 38. Formed in the fitting 38 and communicating at their lower ends with the annular groove 123 are longitudinal passages 124 which, as best shown in Figs. 3 and 4 of the drawings, communicate at their upper ends with an annular passage 125 between the sleeve 37 of the tubular receiver 17 and the booster pump cylinder 67. The annular passage 125 communicates at its upper end with the lower ends of longitudinal passages 126 in the upper intake fitting 36, the passages 126 communicating at their upper ends with an annular groove 127 in the fitting 36. The groove 127 communicates with the annular space 101 containing the discharge valve 102 through radial ports 128 in the booster pump cylinder 67.

Considering the operation of the booster pump 16, during the upward stroke of the motor and pump pistons 22 and 24 of the main pump 15, the booster pump piston 75 is moved upwardly in its cylinder 67 by the rod 30, the booster pump piston being shown in its uppermost position in Fig. 3 of the drawings. During its upward stroke, the booster pump piston 75 discharges well fluid contained in the cylinder 67 thereabove into the annular space 101 containing the discharge valve 102, the discharge valve unseating to permit this to occur. Outflow into the well through the intake ports 95 is prevented by the skirt of the cup-type intake valve 94. From the annular space 101, the well fluid discharged by the booster pump piston 75 enters the discharge ports 63 and ultimately reaches the inlet ports 49 of the main pump 15 through the previously-described intervening passages.

Also during the upward stroke of the booster pump piston 75, well fluid is drawn into the booster pump cylinder 67 beneath the piston through the intake ports 112, the annular groove 111 and the intake ports 110, the skirt of the cup-type intake valve 109 deforming inwardly to permit this to occur. At the same time, the discharge valve 117 closes the longitudinal passages 115 through the intake valve 109.

During the downward stroke of the motor and pump pistons 22 and 24 of the main pump 15, the rod 30 moves the booster pump piston 75 downwardly in its cylinder 67. During its downward stroke, the booster pump piston 75 discharges well fluid contained in the cylinder 67 therebeneath through the longitudinal passages 115 in the intake valve 109 and into the annular space 116 containing the discharge valve 117, the discharge valve 117 opening to permit this to occur. During the downward stroke of the booster pump piston 75, the intake valve 109 closes the intake ports 110 to prevent outflow into the well. From the annular space 116, the well fluid discharged during the downward stroke of the booster pump piston flows upwardly to the discharge ports 63 by way of the radial ports 122 in the booster pump cylinder 67, the annular groove 123 in the intake fitting 38, the longitudinal passages 124 in this fitting, the annular passage 125 between the sleeve 37 and the booster pump cylinder, the longitudinal passages 126 in the intake fitting 36, the annular groove 127 in this fitting and the radial ports 128 in the booster pump cylinder. From the discharge ports 63 the fluid discharged during the downward stroke of the booster pump piston 75 flows upwardly through the previously-described intervening passages to the inlet ports 49 of the main pump 15.

Thus, by discharging well fluid on both strokes of the booster pump piston 75, the booster pump 16 delivers well fluid to the inlet ports 49 of the main pump 15 at a substantially constant rate and at a substantially constant pressure, which is an important feature of the invention.

Referring particularly to Fig. 4 of the drawings, the booster pump 16 includes pressure relief valve means 135 for by-passing fluid discharged by the booster pump piston 75 into the well in the event that the pressure of the well fluid delivered to the inlet ports 49 of the main pump 15 exceeds a predetermined value. The pressure relief valve means 135 is carried by the member 70 which is seated on the pump seat 18 and includes a ball valve 136 carried by a retainer 137 and urged into engagement with a seat 138 by a spring 139. The seat 138 encircles a passage 140 which communicates with a recess 141 in the member 70, the fitting 68 being provided with longitudinal passages 142 which connect the recess 141 to the annular space 116 containing the discharge valve 117. The member 70 is also provided with radial passages 143 which connect the recess 141 to an annular passage 144 between the booster pump 16 and the tubular receiver 17, the annular passage 144 communicating at its upper end with the annular groove 123 in the fitting 38. Thus, well fluid discharged by the booster pump piston 75 may flow into the passage 140 controlled by the ball valve 136 through the longitudinal passages 142 in the fitting 68, or through the annular passage 144.

In the event that the pressure of the well fluid discharged by the booster pump piston 75 rises above a predetermined value for any reason, the spring 138 is compressed to permit the ball valve 136 to unseat, thereby permitting fluid to flow through the passage 140 into a recess 145 containing the ball valve 136, the retainer 137 and the spring 139. The member 70 is provided with radial passages 146 through which fluid may flow from the recess 145 into the well upon unseating of the ball valve 136.

Thus, the auxiliary or booster pump 16 delivers well fluid to the inlet ports 49 of the fluid-operated main pump 15 at an elevated pressure to minimize the formation of gas or air pockets in the pump cylinder 23 of the main pump, whereby to increase the efficiency of the main pump and to minimize the possibility of damage to the components thereof which may result from the formation of gas or air pockets in the pump cylinder 23 as previously discussed. The booster pump 16 preferably delivers a relatively large volume of well fluid to the main pump at a relatively low pressure, the effective cross sectional area of the booster pump piston 75 being substantially larger than that of the motor piston 22 of the main pump to accomplish this. In practice, the ratio of booster pump piston area to motor piston area may be four to one, for example. Thus, the major portion of the work necessary to pump well fluid to the surface is performed by the main pump 15, the function of the booster pump 16 being to deliver the well fluid to the main pump at a pressure sufficient only to prevent excessive formation of gas pockets in the pump cylinder 23 of the main pump, which pressure preferably exceeds the pressure obtaining at the intake ports 95, 97 and 110, 112 of the booster pump.

In the event that the pressure developed by the booster pump 16 rises above the value determined by the spring 139 of the pressure relief valve means 135 for any reasons, the ball valve 136 will unseat to by-pass fluid to the well, as hereinbefore discussed.

As will be apparent, the main pump 15 and the booster pump 16 may be installed in or removed from the well as a unit, the booster pump being slidably positioned in the tubular receiver 17. As hereinbefore discussed, when the main and booster pumps are in their respective operating positions with the booster pump in engagement with the pump seat 18, the sealing ring 45 carried by the main pump provides a fluid-tight seal between the main and booster pumps.

Although I have disclosed an exemplary embodiment of the invention for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in the specific embodiment disclosed without necessarily departing from the spirit of the invention and I hereby reserve the right to all such changes, modifications and substitutions.

I claim as my invention:

1. In a fluid-operated pumping device, the combination of: a fluid-operated main pump of the reciprocating type adapted to be positioned in a well and to pump well fluid from the well to the surface, said main pump being provided with an inlet port; a double-acting auxiliary pump of the reciprocating type provided with intake port means which is adapted to communicate with the well and provided with discharge port means; means providing a closed, pressure-maintaining passage communicating only with said inlet port and said discharge port means so as to maintain fluid pressure in said inlet port substantially equal to that in said discharge port means; and means mechanically connecting said auxiliary pump to said main pump for operating said auxiliary pump so as to pump well fluid from the well to said inlet port at a pressure higher than that in said intake port means.

2. In a fluid-operated pumping device, the combination of: a fluid-operated main pump of the reciprocating type adapted to be positioned in a well and to pump well fluid from the well to the surface, said main pump including connected motor and pump pistons and being provided with an inlet port; a double-acting auxiliary pump of the reciprocating type axially aligned with the main pump and including a pump piston, said auxiliary pump being provided with intake port means adapted to communicate with the well and discharge port means; means providing a closed, pressure-maintaining passage communicating only with said inlet port and said discharge port means so as to maintain fluid pressure in said inlet port substantially equal to that in said discharge port means; and rod means directly connecting said pump piston of said auxiliary pump to one of said pistons of said main pump for operating said auxiliary pump so as to pump well fluid from the well into said inlet port at a pressure higher than that in said intake port means.

3. In a fluid-operated pumping device, the combination of: a fluid-operated main pump of the reciprocating type adapted to be positioned in a well to pump well fluid from the well to the surface, said main pump including connected motor and pump pistons and being provided with an inlet port; a double-acting auxiliary pump of the reciprocating type axially aligned with said main pump and provided with a pump cylinder having a pump piston reciprocable therein, said auxiliary pump being provided with intake port means adapted to communicate with the well and communicating with the ends of said auxiliary pump cylinder, and being provided with discharge port means communicating with the ends of said auxiliary pump cylinder, said auxiliary pump having intake valve means controlling flow of fluid through said intake port means, and having discharge valve means controlling flow through said discharge port means; means providing a closed, pressure-maintaining passage communicating only with said inlet port

and said discharge port means so as to maintain fluid pressure in said inlet port substantially equal to that in said discharge port means; and rod means directly connecting said auxiliary pump piston to one of said pistons of said main pump for operating said auxiliary pump so as to pump well fluid from the well into said inlet port at a pressure higher than that in said intake port means.

4. A fluid-operated pumping device as set forth in claim 2 wherein said auxiliary pump includes a balance chamber and wherein said rod means is tubular and extends into said balance chamber.

5. In a fluid-operated pumping device, the combination of: a fluid-operated main pump of the reciprocating type adapted to be positioned in a well to pump well fluid from the well to the surface, said main pump including connected motor and pump pistons and being provided with an inlet port; a double-acting auxiliary pump of the reciprocating type axially aligned with said main pump, said auxiliary pump including a pump cylinder having a pump piston reciprocable therein, said auxiliary pump being provided with intake port means adapted to communicate with the well and discharge port means; means providing a closed, pressure-maintaining passage communicating only with said inlet port and said discharge port means so as to maintain fluid pressure in said inlet port substantially equal to that in said discharge port means; rod means directly connecting said auxiliary pump piston to one of said pistons of said main pump for operating said auxiliary pump so as to pump well fluid from the well into said inlet port at a pressure higher than that in said intake port means; and pressure relief valve means carried by said auxiliary pump cylinder for by-passing fluid from said discharge port means to the well.

6. In combination with production and power tubings set in a well and a tubular receiver which is connected to one of said tubings and which is provided with a seat, a fluid-operated pumping device adapted to be inserted into said receiver and to seat on said seat, comprising: a fluid-operated main pump of the reciprocating

type provided with connected motor and pump pistons and an inlet port; a double-acting auxiliary pump axially aligned with said main pump, said auxiliary pump including a pump cylinder having a pump piston reciprocable therein, and said auxiliary pump being provided with intake port means adapted to communicate with the well and discharge port means; means providing a closed, pressure-maintaining passage communicating only with said inlet port and said discharge port means so as to maintain fluid pressure in said inlet port substantially equal to that in said discharge port means; and rod means directly connecting said auxiliary pump piston to one of said pistons of said main pump for operating said auxiliary pump so as to pump well fluid from the well into said inlet port at a pressure higher than that in said intake port.

7. A fluid-operated pumping device as defined in claim 2 wherein said auxiliary pump is secured to said main pump so that said main and auxiliary pumps are installable in and removable from the well as a unit.

8. A fluid-operated pumping device as defined in claim 6 wherein said auxiliary pump is secured to said main pump so that said main and auxiliary pumps are insertable into and removable from said receiver as a unit.

9. A fluid-operated pumping device as defined in claim 6 including annular sealing means carried by said pumping device intermediate said main and auxiliary pumps and adapted to engage said receiver in fluid-tight relation therewith.

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